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THE COURSE OF THE SENSORY FIBERS IN THE SPINAL CORD AND SOME POINTS IN SPINAL LOCALIZATION BASED ON A CASE OF SECTION OF THE CORD.*

By MORTON PRINCE, M.D.,

of Boston.

PROFESSOR OF NERVOUS DISEASES, TUFTS COLLEGE MEDICAL SCHOOL.

The afferent fibers in the cord pass upwards in the dorsal and antero-lateral columns. Which tracts convey sensory impulses, and whether there is a crossing in the cord has not yet been proved.

Function of the Posterior Columns.—The function of the long posterior columns has never been definitely made out, though it has been well established that the path is largely made up of long fibers which coming from the posterior roots of the same side ascend directly to the dorsal column nuclei in the bulb. From here the next neurone in the chain crosses the median fillet to the opposite side to ascend by paths which are still the subject of dispute to the cerebral cortex.

Experimental Evidence.—Aside from the contradictory results of experimentation in animals, this kind of evidence is unsatisfactory inasmuch as there is reason to believe that the course of the sensory tracts in animals differs from that in man.

Schiff,[1] from his experiments, maintained that after transection of all the columns except the dorsal, signs of sensation could still be evoked from the parts below the section. Herzen[2] and others confirmed this view that these columns were especially for tactile sense. Osawa,[3] on the contrary, in similar experiments found sensation entirely abolished. Indeed severence of the posterior columns has been performed by different experimenters many times[4] at different levels without perceptible impairment of sensation. Borchert[5] gives a careful résumé of the results of posterior and lateral tract section in 11 dogs and 2 foxes. In no case where the posterior columns alone were cut was there any disturbance of tactile perception.

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* Read at the meeting of the American Neurological Association, June 5, 6 and 7, 1902.

The impression is growing from recent experiments[6] that the posterior columns are largely for the conduction of muscular rather than tactile sense, and there is much in favor of the view adopted by Hering,[7] that they serve to conduct centripetal impulses which, arising in the apparatus of movement, regulate by unconscious reactions the movements of the skeletal musculature. Yet Meyer's case seems to show that they are capable of conducting tactile sensation.

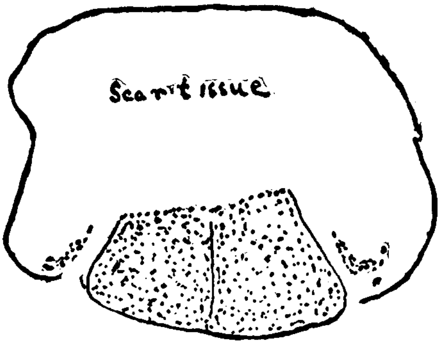

Fig. 1.—Cut from Meyer's article.

The lack of pathological data in most cases of incised wounds in the cord, and the absence of sharply circumscribed lesions in the other cases that have come to autopsy have made physiological study from this source difficult. Meyer's[8] case is important in that the lesion ("Myelitic destruction") was sharply defined though of slow development. There was destruction of the entire cross-section from the 4th to 6th thoracic segment, with the exception of the dorsal two-thirds of the posterior columns and a few pyramidal fibers which were intact. (Fig. 1.) "Tactile sensibility is normal, also localization," the report says, but analgesia and thermanesthesia were present below the 6th rib. It is to be regretted that the method of testing tactile sensibility is not given, particularly as the patient was insane and presented marked defect of memory suggestive of Kortchakoff's psychosis (anterograde amnesia). Details of the microscopical appearances and the technique employed are not given. The possibility that loss of function was not as great as the anatomical appearances indicated (as so frequently is the case) must be considered and might explain the loss of tactile sensation, otherwise it would seem that tactile sense must have been transmitted by the posterior columns in this case, though pain and temperature impressions failed to be transmitted. If this is the rule for tactile impressions it is hard to explain why many cases of tabes with extensive degeneration of the posterior columns should have little or no disturbance of tactile sensation unless there are other paths of sensation. Further the supposition that the posterior columns are the sole or chief conductors of sensibility is incompatible with the clinical condition known as Brown-Séquard paralysis where the crossed sensory paralysis below the lesion indicates a crossing in the cord. The posterior tracts cross only above in the bulb. Another possible interpretation of Meyer's case is that the development of the lesion, being gradual, the posterior columns took on functions that ordinarily are performed by the antero-lateral columns. That is to say, that there are two paths for sensation, the chief being the antero-lateral columns. In slow developing lesions of these, the posterior columns may take their functions. This case of Meyer's is the direct complement of my case in which both the posterior columns were cut without loss of tactile sense on one side.

Function of the Lateral Columns.—Tactile Sense.—There is experimental evidence strongly suggesting that at least one of the paths of conduction of tactile sense is in the lateral part of the cord, though this evidence is conflicting as to whether this path is crossed or not. Borchert,[5] after section of the posterior and lateral columns on the right side of a thoracic cord, and the posterior alone on the left, found tactile sense lost below on the right but intact on the left. A similar experiment in a lumbar cord gave a corresponding result. These experiments were both on dogs, and it will be noticed that the anesthesia *corresponded to the side of the lesion*. This observation agrees with the experiments of Mott[9] and Schäfer[10] on monkeys. Mott concluded that, in these animals, while pain and temperature sense are conducted on both sides of the cord, tactile and pressure sense are conducted only along the same side of the cord. Weiss[11] performed hemisection in the dog, and found that sensibility became after a time restored on the side of the lesion, but remained permanently impaired in the *contralateral* limb differing in this respect from Borchert and Mott. Both Ferrier and Turner, too, as a result of hemisection of the cord in monkeys found that tactile sensation passed up the opposite half of the cord. The difficulty met in my case in determining the exact area incised in each half of the cord impressed upon me a possible source of error in physiological experiments, and a possible reason for contradictory results.

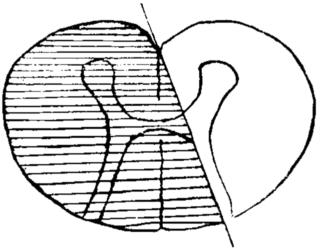

Fig. 2.—Cut from Müller's article.

As to *pain and temperature*, the evidence is convincing that their conducting paths are not only crossed but also that, probably after the first synopsis, they run in the lateral columns, though some observations on animals, as those of Mott and others, are interpreted as showing both uncrossed and crossed conduction. Schiff[12] and also Budge[13] erred in concluding from vivisection experiments that pain is conducted in the gray matter, for many experiments show the gray matter incapable of conducting a long distance.[14] They may be right, though, in holding that only those fibers conduct pain that end in the gray matter thus excluding the posterior columns. Brown-Séquard,[15] from clinical studies after wounds of the cord and both Ferrier,[16] and Turner,[17] as a result of the experiments above referred to on monkeys, concluded that *pain* impulses crossed soon after entrance and passed up the opposite half of the cord. Miescher[18] and Woroschilloff[19] also obtained the result that, in the rabbit, these impulses ascend in the lateral columns. Sherrington[20] reached the same result in the dog as indicated by blood pressure impulses. Both Miescher's and Sherrington's experiments indicated that the impulses crossed in the cord. Others[21] claim that the conduction from one side of the body is by both lateral columns in about equal proportion. The value of these experiments has the necessary limitation of observations on dumb animals, and, whatever the reason, this experimental evidence while showing conduction of sensibility in the lateral columns, is conflicting in regard to whether the condition is by the same or the opposite side for tactile sensations, and by only the opposite or both sides for pain and temperature sensations.

Clinical pathology will probably have to settle the questions in dispute. The great difficulty is that of obtaining pure cases of limited lesions. There is some evidence in hand.

Myer's case pointing to tactile conduction by the posterior columns has already been described.

Gowers[22] describes an important case of injury to the cervical cord by a spicula of bone and hemorrhage. As figured in a cut (not very distinct) the injured area was limited to the gray matter and antero-lateral region, bounded behind by the posterior horn and anteriorly by a line not quite as far forward as the anterior roots. It thus involved the triangular region, which in my case seems to contain the paths for tactile sensations. Gowers found entire loss of sensibility to pain (and temperature) *without impairment of tactile sensibility*. (Query: Did the hemorrhage which occasioned the damage in the anterior portion of the triangle actually destroy conduction?) This case is in harmony with that of Meyer, but Gowers erroneously and unaccountably quotes a very important case of Müller as a complement of his own case, and as corroborating the view that the tactile sensations are conveyed by the posterior columns. The case was one of knife stab of the dorsal cord. The *whole of the left half of the cord* was severed, but only the *posterior columns of the right half* (Fig. 2). Gowers states that tactile sensation was lost on both sides, and pain on the right only.

Examination of the original report[23] shows tactile sensation was not lost but only diminished on the left side; i.e., "Slight [oberflächliche] touch from the fourth intercostal space downward was not perceived." On the other hand the left side was very sensitive (sehr empfindlich) to "more intense stimulation [intensivere Reize] (pressure, percussion, cold)" and the patient declared that "lebhaftes stechen" were felt. Tested with faradic electricity on the day after the injury a trifling [unbedeutender] current was felt on the left side as very painful. On the right side there was absolute anesthesia for touch and pain; intense stimulations, including moderately strong faradic currents, were not felt at all. Four days later it was noted that somewhat stronger pressure upon the muscles of the lower half of the body on the left elicited severe pain. Later still, on the left, "the hyperesthesia abated; less intense electrical currents were perceived, but not so painfully as before."

The symptoms are thus summed up by the author: "On the side of the section; motor paralysis, hyperesthesia for pressure, pain, and the electrical current, contraction of the pupil. On the opposite side; free mobility and complete anesthesia for all sensory impressions." He further affirms that the syndrome was in entire accord with the Brown-Séquard theory, that the crossing of the sensory conducting tracts takes place throughout the whole length of the spinal cord, etc. The Brown-Séquard syndrome which this case is held to exemplify, is stated to be "paralysis on the side of the injury with hyperesthesia for touch, temperature, pain, tactile sense contraction of the corresponding pupil. On the opposite side preservation of movement with complete anesthesia for every form of sensation."

From this report it is plain that tactile sensation was not more than slightly diminished, (what well might have been due to edema of the uncut portion of the cord) and the completely severed posterior column could not have been the path of conduction for the tactile impressions that were conveyed.

This case therefore is contradictory of Gowers' case, and in entire agreement with the clinical findings in my case.

In this connection it is significant that Bechterew and Holzinger,[24] in their experiments on dogs, found that neither section of the posterior columns together with the anterior columns, nor section of the anterior portion of the cord, (that is, anterior column and anterior portion of the lateral columns) caused analgesia; but that analgesia followed only after section of the whole of both lateral columns or after section of the posterior half of the cord provided that the anterior limit of the section was a little in front of the pyramidal tracts. In other words, pain conduction was found to lie in the same triangular region in which the findings in my case show that conduction of tactile impressions occurred.

Dejerine and Thomas[25] in connection with a case of syphilitic hemiparaplegia with crossed anesthesia, conclude that in man the majority of facts seems to favor total or almost total decussation of the "sensory fibers in the cord." But they admit this conclusion can not be extended to the higher animals; i.e., in the dog and monkey the crossing is certainly incomplete. The ascending degeneration in their case was almost confined to the direct cerebellar and Gowers' tracts on the side of the lesion. The posterior columns were practically normal. The muscle-sense was normal and tactile sense was only slightly impaired in the non-paralyzed leg, but the pain and temperature senses were much enfeebled.

Recently the idea has been growing that there are two possible paths for tactile sensation, one capable of substitution for the other. In this connection Petrén[26] concludes from a clinical study that hemilesions of the cord give only crossed anesthesia, which may be either a disturbance of all the skin senses together or, more commonly, a dissociated type including pain and temperature senses only (the pressure or tactile sense being normal). The great majority of cases of disturbed tactile sense show also paralysis of the opposite limb. Petrén concludes that tactile sense in the cord is conducted over two paths,—one in the uncrossed tract of the posterior column, the other following the tracts of common sensation. These latter cross,—for the lower extremity,—at the 12th dorsal or 1st lumbar segment and gradually work laterally till they lie about at the root of Gowers' tract. These conclusions are in harmony with Meyer's and my case.

Ballati's[27] recent conclusions are similar, and he adds that dissociation of sensibility by medullary compression must arise from incomplete lesion of Gowers' tract.

It has been assumed that a pain tract does not also conduct tactile impulses but, in spite of the extensive work of Herzen[2] and

Goldscheider[28] in this direction, it is hardly proven. Pain may be only a result of an intensification of the impulses that ordinarily would be felt as touch.

To summarize, it is impossible to harmonize all the experimental evidence bearing on the various problems which arise in regard to the transmission of sensibility in the cord, and particularly of tactile sensation. Anatomically one must expect the conduction in the cord to be by either the posterior or antero-lateral tracts, or by both. The case here reported proves that tactile sensation is conducted through the antero-lateral columns, and it is difficult to interpret the findings unless this conduction is crossed. The supposition of two possible paths of tactile conduction would explain the otherwise contradictory cases of Meyer and the author. Moreover, as already stated, the case of Meyer might be further explained on the double path basis by presuming, since the lesion was of slow progress, that the second path could readily take up the lost function, while in sudden onset there would be temporary anesthesia. This idea, too, would agree with the findings of Brown-Séquard[29] where the hemisection of the cord at different levels made him abandon his well-known theory.

Case of Stab Wound of the Cord.—The value of the following observation lies in the fact that the case was one which was practically of the nature of a vivisection by which the cord was partially severed in the cervical region. Although both sides of the body were paralyzed below the seat of the lesion, tactile sensation was destroyed only on one side. It, therefore, would seem, that, first; if we could determine the exact line of incision of the cord on the two sides, we might be able to throw some light on the paths of conduction for the sense of touch: second, as the incision was sharply made between the sixth and seventh segments it would contribute to our knowledge of spinal localization. The vivisection experiment was due to the fact that two Italians got into a brawl and one stabbed the other in the neck with a knife. The point of entrance was one and a half inches behind and one below the mastoid, and the probe showed that the wound went downward and slightly forward and inward to what was apparently the body of the sixth cervical vertebra. As will be presently seen examination of the cord showed this same diagonal direction of the knife. The patient was at once brought to the City Hospital. On entrance, the evening of December 9, about an hour after the affair, it was noted by Dr. Beebe, the house surgeon, and recorded in the records that at this early period "sensation was preserved in the entire left leg, but *entirely absent in the right leg.*" There was complete paraplegia and bilateral paralysis of certain movements of the arms which will be later described in connection with the localization of movements. The knee-jerks are described as lively. I saw the patient the following morning, perhaps twelve hours after the injury, and a careful examination then showed that this same hemianesthesia existed on the right side, but the patient could

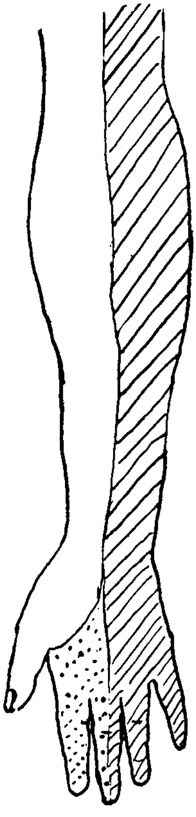

Fig. 3.—Right hand. Shaded area, absolute anesthesia. Dotted area, blunted sensibility.

feel the slightest touch all over the left side: On the right side the anesthesia was profound, so much so that it was easy to map out the line of demarcation in the hand and arm between the normal and anesthetic skin. This line ran down the middle of the forearm and palm of the hand to the middle finger, which was included in the anesthetic area. The temperature sense was not tested. No note was made in the records of the condition of the pain sense. It can not, therefore, be positively stated as a fact that it was lost. But my *recollection* is clear, that a pin prick was used as a test and was not felt; and second, as, in organic lesions, pain is always lost when the loss of tactile sense is absolute, it is highly improbable that the sense of pain was retained. There was absolute paralysis of both legs and of the hands as will be later described. The knee-jerks at this time had become lost, as were all other reflexes in the paralyzed parts.

The injury of the cord was localized correctly as was afterwards proved, at the height between the sixth and seventh cervical segments.

The patient died about four days after the injury on the evening of December 13. At the autopsy the cervical cord was removed with its inclosing vertebræ. The cord, in situ, and the vertebræ were then cut longitudinally, and the whole hardened in formalin. The cord was thus divided, for purposes of examination, into two lateral halves by an incision which passed very sharply antero-posteriorly along the anterior fissure and posterior septum close to or through the central canal. It could be then seen that the stab had made an incision of the cord, which, roughly speaking, severed the posterior half. On the posterior surface the knife of the assailant had cut the cord *diagonally* from above, on the right, to below, on the left, approximately between the sixth and seventh segments. On the right side the incision was sufficiently high to cut two (8th and 9th) filaments of the sixth posterior root, leaving intact the last (10th) filament, while on the left side it passed sharply *between* the sixth and seventh roots and on this side extended forward nearly to a point *half way between the anterior and posterior roots.* On the right side the anterior limit was not at this time determined, but on the median surface the anterior limit of the incision in the middle line could be plainly made out. Here the incision, the edges of which were somewhat jagged from necrosis, extended to and through the longitudinal line marking the gray matter and ependyma around the central canal; (Fig. 4) so that, as was later determined by the microscope, the anterior limit of the section in the median line was just through the anterior

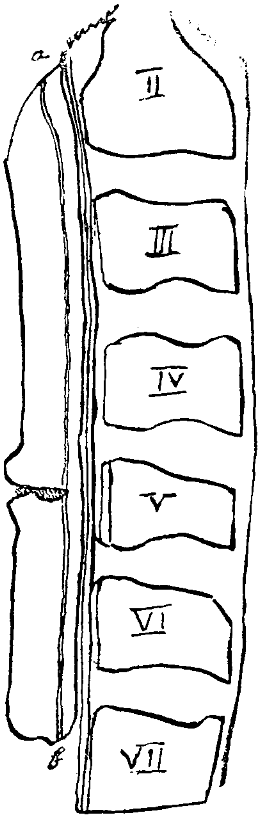

Fig. 4.—Tracing of median surface of left half of spinal cord with vertebræ, made by placing tracing paper over the specimen. The cord has been cut antero-posteriorly along the anterior fissure and posterior septum. The line a b marks the gray matter around central canal. The incision is seen to extend through it.

commissure, and at the periphery on the left side at a point approximately half way between the exit of the anterior and posterior roots. On the right side the anterior limit of the incision was determined by the microscope. The important point was to determine the extreme anterior limit of the incision. For this purpose (after making a series of experiments on another cord in which a similar incision was made), the method was adopted of injecting the incision with a mixture of carmine and mucilage. Under the microscope it was found that the presence of the carmine particles marked the line of incision. Serial sections were then made from a point just above the highest point of incision through the whole of that part of the cord which included the incision. The knife had entered on the right side and, held at a certain angle, had passed downwards, forwards and across the cord. In the transfixion the knife came out farther forward on the left side than its entrance on the right. Thus a greater area of the left half of the cord than of the right was cut, but the *posterior columns were completely severed on both sides.* Approximately the posterior two-thirds of the cord was severed on the left side. As the knife passed slantingly across, it is apparent that at no one level were all the fibers cut, but at each descending level new bundles were included in its swathe.

The peculiar effect of a diagonal cut on a transverse section was to show at each level only a more or less sharply defined slit running from behind forwards, i.e., for example, from the periphery towards the lateral horn on the right, and approximately parallel to the posterior horn. In each level of descent this slit shifted its position from right to left, but kept its same general direction. Approaching the posterior horn, it passed across it, then approaching the median septum, crossed it and finally in a similar way passed over the left lateral columns which were thus extensively severed. This slit, or incision at each succeeding level below was necessarily farther to the left than that in the level above. This will be understood if one pictures to one's self that the effect of a longitudinal cut on each transverse section would be a slit running postero-anteriorly but occupying the same position at every level. In a diagonal cut the slit must shift its position at each level. In some levels in this particular case, particularly on the left of the picture, this was altered by the softening which had taken place in parts of the cut surface converting the slit into a jagged opening, or allowing the specimen to be torn in the cutting. In the microphotographs (Figs. 5 and 6) the carmine granules marking the slit, X, can be seen. Fig. 5 represents the higher level.

In Fig. 6 the slit is approaching the posterior horn. (This peculiar appearance of each transverse section was demonstrated on a model on which a similar cut was made.) This is shown diagrammically in Fig. 7. The line of incision at each level in the right half of the cord was seen to be full of the injected carmine granules and could be easily recognized; in the left half of the cord the injection was not so successful. The extreme anterior limit of each slit necessarily marked the anterior limit of the section of the cord at each level. By means of an Edinger projection apparatus each transverse section was magnified and transferred to tracing

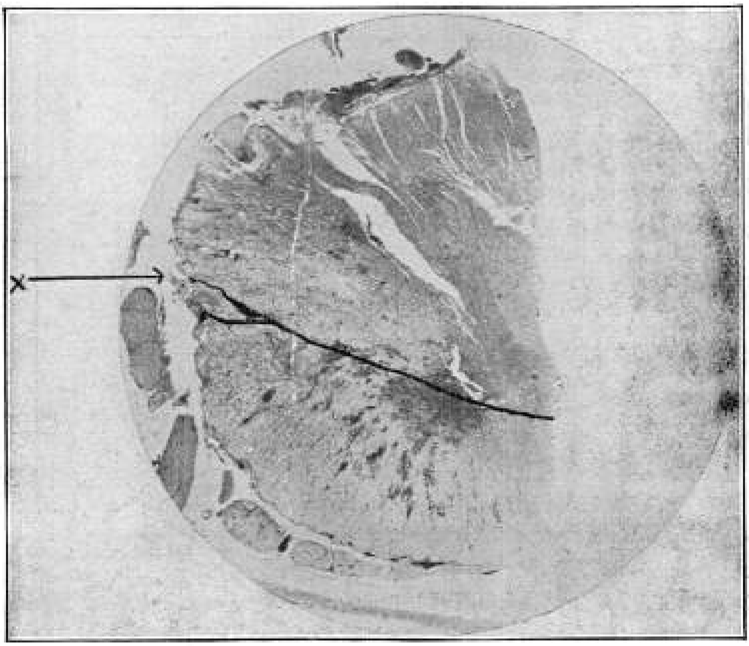

Fig. 5.—Photograph of right half of cord near the upper level of incision. The arrow points to cleft with carmine granules. The black line running from the anterior fissure to the periphery has been drawn on the photograph through the points marking the anterior limits of the incision at each level, plotted on one plane. These points make a straight line. Thus, it will be noticed, the carmine injection at this level terminates in this line. The hemorrhages in the antero-lateral field are conspicuous, but some of the dark spots are blood vessels. The separation of the posterior horn from the white matter is an artifact.

paper. By superimposing each tracing, one upon another, it was easy to plot on a single plane the severed area of the cord. Wherever the carmine adhered every section agreed relatively with one another, and the anterior limits made a straight line from the anterior commissure to the periphery. This plotting, corroborated by the microscope, is shown in Fig. 8, line ab.

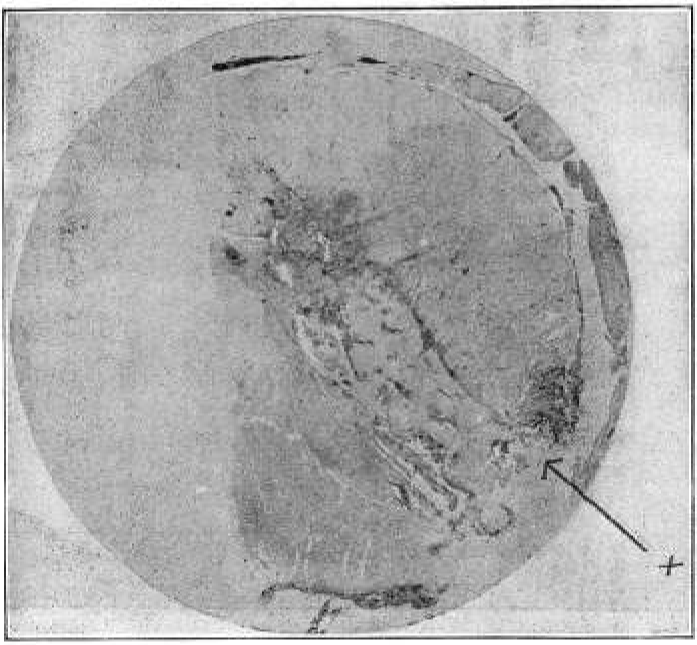

Fig. 6.—Photograph of section at a level a little lower that Fig. 5. Line of incision, X, is approaching the lateral horn, and has extended anteriorly into the anterior horn, which is disorganized by hemorrhage. A second and parallel cleft is seen extending the whole length of the posterior and into the anterior horn. This is probably an artifact, and a continuation of the artifact seen in Fig. 5. Below it disappears. As this area was also cut a little lower down by the incision (X) the findings in any event would not be affected.

In the anterior field, at the higher level (Fig. 5), on the right, there were a number of small hemorrhages scattered and separated by nerve fibres. It might be questioned whether these could have caused the loss of tactile sensation on the same side. If so it would locate the sensory fibers well forward without crossing, but we could not then explain the prevention of sensibility on the left side. Opposed to this interpretation is the fact that the hemorrhages were discrete in islets, while the anesthesia involved the whole half of body. The examination of the specimens themselves does not give the impressions that conduction was extensively interfered with by these hemorrhages.

In the left half of the cord it was difficult to determine the exact anterior limit at and towards the periphery, as the carmine particles did not adhere well, and because in the lowest levels the postero-lateral portion was torn in the preparation owing to softening. Still in a sufficient number of sections the carmine particles adhered to give an anterior line, and at the periphery the free end of the cut membrane gave the terminal point. The various points made a fairly straight line. The anterior limit of the cut area was thus shown by the microscope to be somewhat farther forward than appeared to be the case with the naked eye. It could be determined with positiveness that the section of the left half of the cord extended considerably further forward through the lateral columns than on the right. *This could also be determined macroscopically* so that this fact is indisputable. It will be remembered that macroscopically the incision on the left reached a point approximately half way between the anterior and posterior roots. Further, the microscope showed that numerous hemorrhages had taken place into the left lateral field. These hemorrhages would

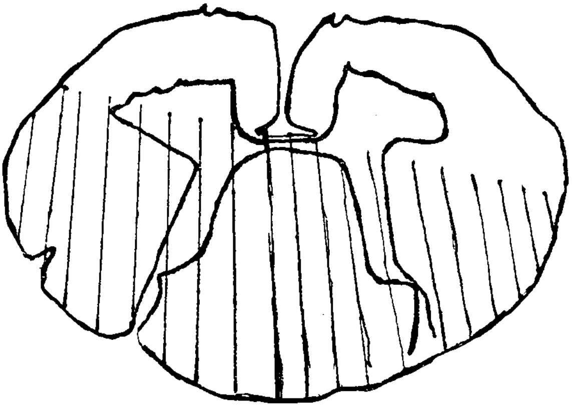

Fig. 7.—Composite diagram showing appearance of incision at each level.

probably have impaired the function of this column even if not cut. The exact anterior boundary on the left side is therefore approximate. (Owing to the short time which elapsed before death the Marchi staining failed to reveal degenerated fibers, and this method could not be utilized.) In the median line the anterior limit of the section was just in front of the anterior commissure.

It is thus determined that the knife entered the cord on the right side at a point that would correspond approximately to the anterior border of the pyramidal tract, then passed inward and forward to the central canal and anterior commissure which it included, swept over to the left, where it followed a line running from the central canal to a point in the periphery still farther forward and somewhat anterior to (or at?) a point half way between the anterior and posterior roots.

Referring to Fig. 8 in which the line of section, ab, has been plotted, it will be seen that the whole of the posterior columns have been divided, and that while on the right side the section passed through the anterior portion of the pyramidal tract without including the antero-lateral field, on the left side a considerable portion of the antero-lateral columns were included. Thus a larger area was cut on the left than on the right.

If we draw an imaginary line, c, on the right, corresponding to the line of incision on the left, we find that we have a triangle, the anterior limb of which will be this imaginary line; the base the periphery of the cord; the apex the anterior commissure, and the posterior limb the line of incision on this side. This triangle is located in the antero-lateral column and represents approximately the additional area cut in the left half of the cord. In includes:—

(a) A portion of Gowers' tract. (b) A portion of the cerebellar tract. (c) A portion of the lateral ground bundle.

Aside from the two first tracts it is well known that centripetal fibers ascend in the lateral ground bundle coming from the gray matter of both the same and opposite sides.

The following conclusions may be drawn from these findings:

First, The whole of the posterior columns and posterior horns were destroyed, and yet tactile sensation was preserved on one side. From this it is positively proved that tactile sensations are conducted by other paths than by the posterior columns, but it cannot be inferred that the posterior columns are not also conduction paths of sensation.

Second, It is probable, thought not certain, that the same conclusions apply to pain impressions (see history).

Third, Inasmuch as the whole of the area destroyed on the right was equally destroyed on the left, if we exclude the scattered hemorrhagic foci on the right, there seems to be no way of interpreting these findings excepting on the supposition that the right hemianesthesia must have been due to the incision of the lateral columns on the *left*. That is, a path for sensibility must cross in the cord; for if the right hemianesthesia were due to the section of the right half of the cord, as the same area was destroyed on the left, left hemianesthesia would also have been present. This is in agreement with the case of incision of the cord reported by Müller.

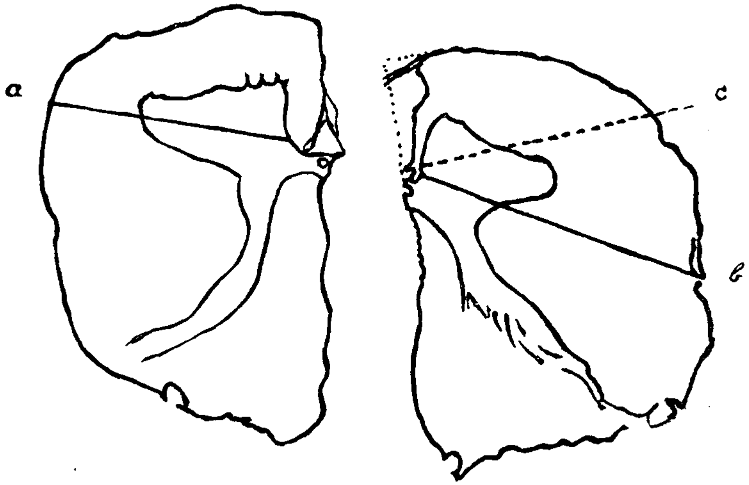

Fig. 8.—Traced and plotted by means of an Edinger projection apparatus from the different sections. The section of the left half of cord is at a lower level than that of the right half; hence the difference in shape of outline of gray matter. The peripheral limit of the imaginary line (C) is taken at the same distance from the anterior fissure as that of the incision (a).

Fourth, A path for the conduction of sensibility must lie anterior to the line of incision on the right and approximately in the area bounded by the above-described triangle in the lateral column; for if this path lies much anterior to this triangle, as it was not cut on the left sensation would have been preserved on the right. (The possibility must be considered that this sensory tract may extend still farther forward, and in this case have been impaired by edema. That the hemianesthesia was found within an hour after the injury indicates that it was not due to secondary inflammation). The only alternative is the location of the tactile conducting path in the anterior field without crossing (seat of the disseminated hemorrhagic foci).

Fifth, There was unilateral priapism, the vascular engorgment being on the left side, that on which the largest area of the cord was divided. The relation of this to the lesion is not clear.

Sixth, As there was absolute paraplegia the uncrossed motor tract could not convey motor impulses of consequence.

Seventh, The anterior horn on the right (the side of the hemianesthesia) was extensively destroyed by hemorrhages. Physiological experiments indicate that sensory conduction is not by way ot the gray matter. This case, however, does not disprove this interpretation. The extensive hemorrhages on the left side were in the white matter and mostly posterior to the line of incision.

Eighth, These findings of crossed sensory paths in the lateral columns are in accord with the clinical Brown-Séquard syndrome, to wit, anesthesia on the side opposite to the lesion in the cord. This syndrome is incompatible with the view that sensory conduction is by the posterior columns, for as the fibers in these columns are known to cross above in the fillet, if they also crossed in the cord there would be a double crossing, and consequently in cerebral disease hemianesthesia would be on the same side as the lesion.

Spinal Localization.—The height of the incision was correctly diagnosed during life, viz., between the 6th and 7th segments. A comparison of the anatomical findings with the clinical manifestations shows some deviations from the usually accepted views of spinal localization. Flexion of the arms was strong and in contrast with the absolute paralysis of extension. The center for the triceps is usually placed in the 6th, 7th and 8th cervical segments. The absolute paralysis of this muscle present in this case in both arms indicates that the center is not above the 7th segment. The wrists could be flexed and extended, though weakly, on both the ulnar and radial side, showing that the center for these movements must extend in part above the 7th segment, at least into the 6th, though Wichmann places the flexors of the wrist entirely below the 6th segment.

Pronation and supination were possible, though impaired; the latter was the stronger.

All movements of the fingers were lost, corresponding to the location usually accepted, though Wichmann extends the centers for the long extensors of the fingers, the flexor longus pollicis, flexor brevis pollicis, and opponens pollicis upward into the 6th segment.

Summing up, the main points for the localization of the lesion between the 6th and 7th cervical segments would be the absolute paralysis of triceps and all movements of the fingers, with normal strength of the deltoid and flexors of the forearm, all other movements being simply weakened.

Sensation.—The line of division between normal and anesthetic skin down the middle of the forearm to the middle finger corresponds very closely with the distribution of the 6th and 7th nerve roots as given by Starr, but differ slightly from that by Kocher, Wichmann and others.

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